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Dunn et al.

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(54) **SYSTEM AND METHOD FOR DYNAMIC LOAD SHARING BETWEEN ELECTRONIC DISPLAYS**

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G09G 5/00 (2006.01)
G06F 3/14 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/14*** (2013.01); *G09G 2320/0626* (2013.01); *G09G 2330/021* (2013.01); *G09G 2354/00* (2013.01); *G09G 2360/144* (2013.01); *G09G 2370/022* (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/14; G09G 2320/0626; G09G 2330/021; G09G 2354/00; G09G 2360/144; G09G 2370/022; H02J 3/04; H02J 17/00; H02J 5/005
See application file for complete search history.

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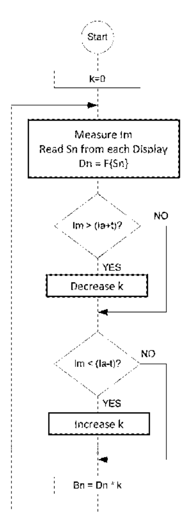
(57) **ABSTRACT**

A system and method for allocating power to a plurality of displays is disclosed. An exemplary system preferably includes an AC current sensor, a power load sharing controller, ambient light sensors for each display, and a brightness controller for each display. A maximum total current draw may be selected. The ambient light contacting each display may be measured and a corresponding desired brightness calculated. Depending on the present amount of current draw, the system determines if the displays can be driven at the desired brightness without exceeding the maximum total current draw. If yes, the displays are driven at their desired brightness. If no, the desired brightness for each display may be slightly reduced to prevent exceeding the maximum total current draw. Thus, as the ambient light varies between the displays, the available power may be shared.

11 Claims, 4 Drawing Sheets



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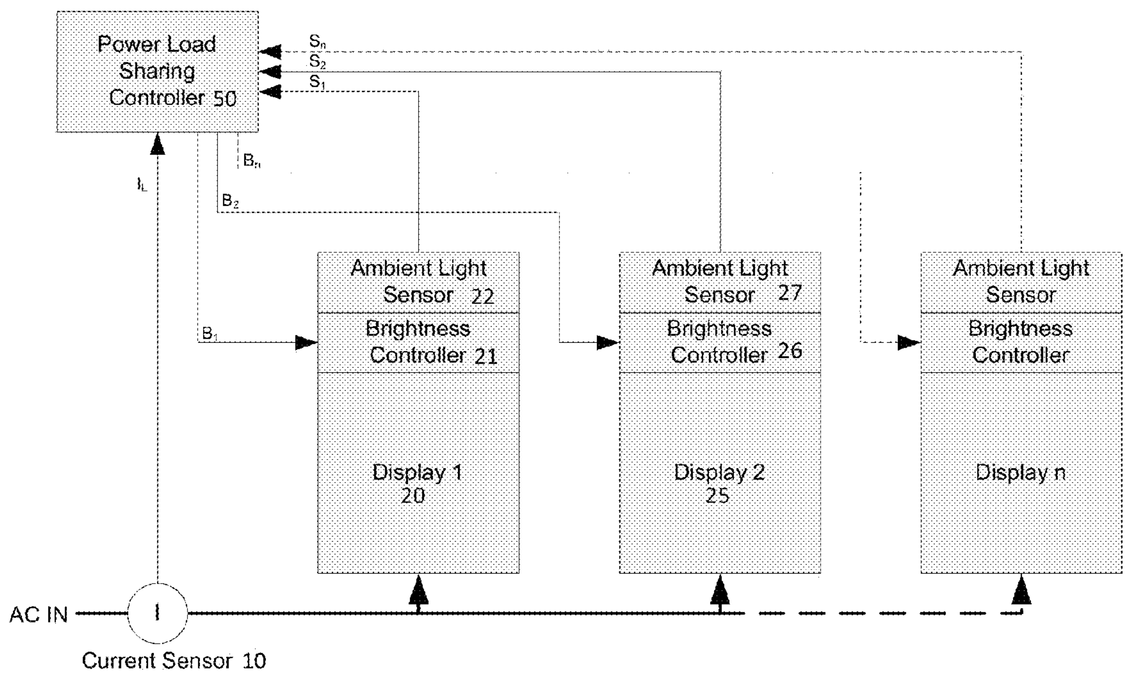

Power Load Sharing Controller 50
S_n
S_2
S_1
B_n
I_L
B_2
B_1
Ambient Light Sensor 22
Brightness Controller 21
Display 1 20
Ambient Light Sensor 27
Brightness Controller 26
Display 2 25
Ambient Light Sensor
Brightness Controller
Display n
AC IN
I
Current Sensor 10

FIG - 1

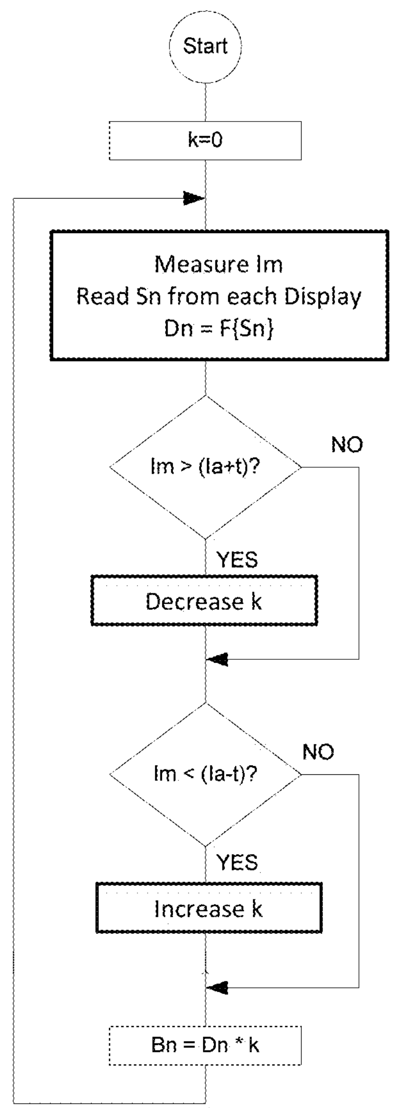
Start
k=0
Measure Im
Read Sn from each Display
Dn = F{Sn}
Im > (Ia+t)?
NO
YES
Decrease k
Im < (Ia-t)?
NO
YES
Increase k
Bn = Dn * k

FIG - 2

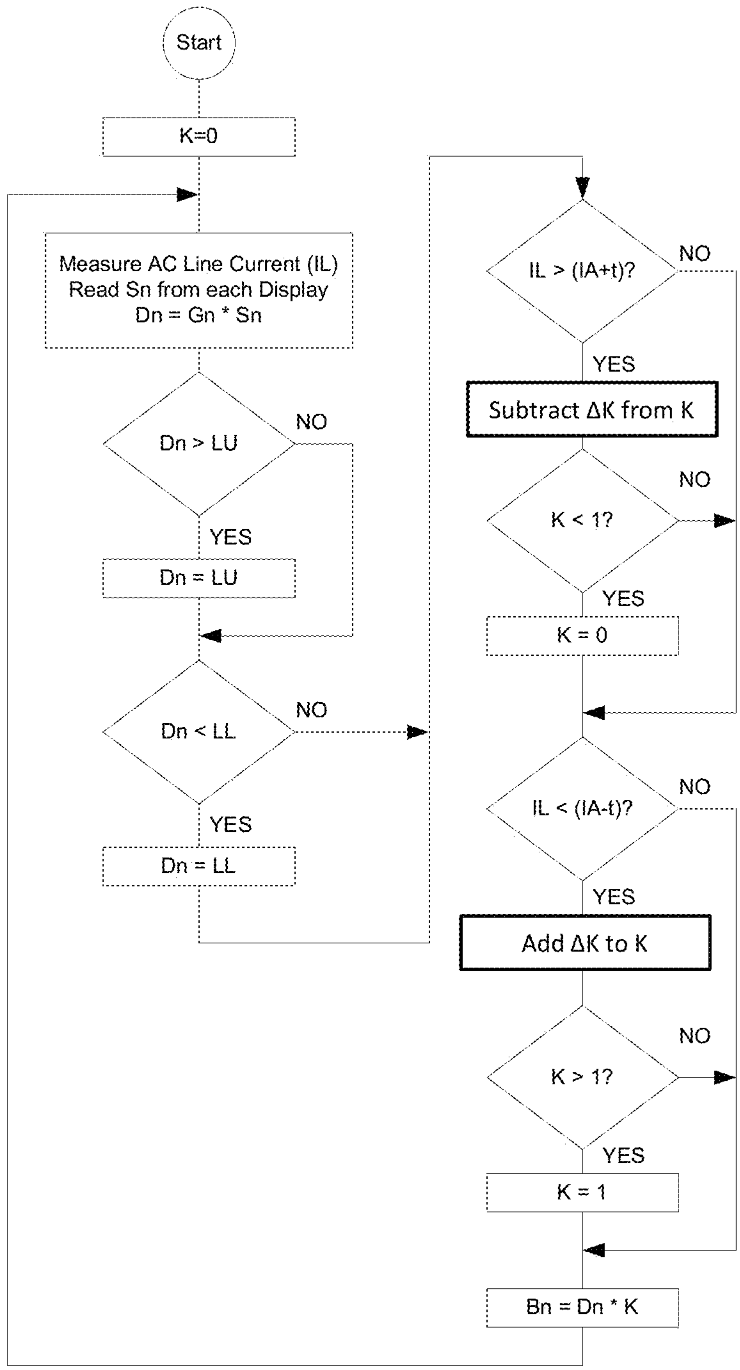
Start
K=0
Measure AC Line Current (IL)
Read Sn from each Display
Dn = Gn * Sn
Dn > LU
NO
YES
Dn = LU
Dn < LL
NO
YES
Dn = LL
IL > (IA+t)?
NO
YES
Subtract ΔK from K
K < 1?
NO
YES
K = 0
IL < (IA-t)?
NO
YES
Add ΔK to K
K > 1?
NO
YES
K = 1
Bn = Dn * K

FIG - 3

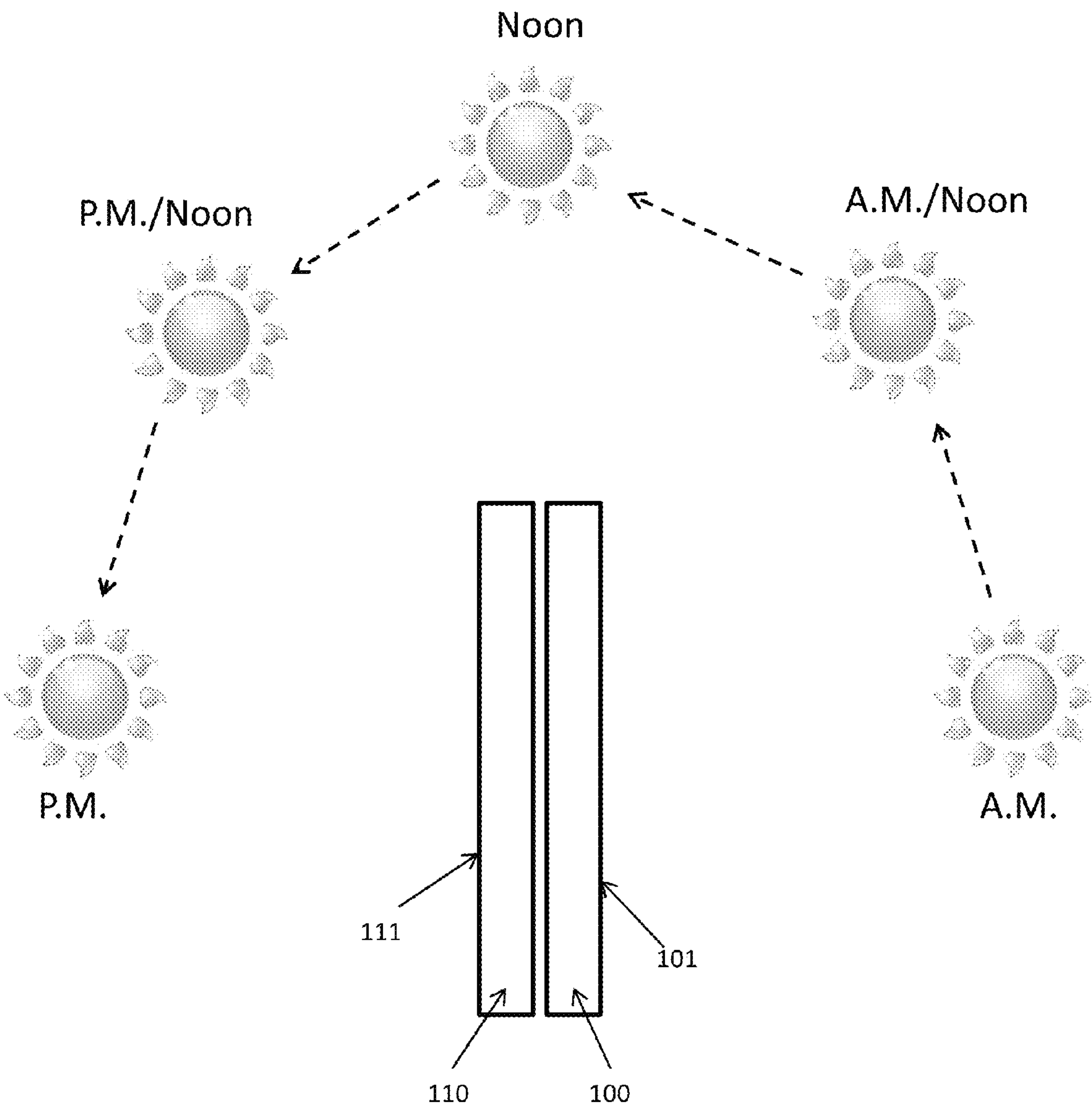

FIG - 4

SYSTEM AND METHOD FOR DYNAMIC LOAD SHARING BETWEEN ELECTRONIC DISPLAYS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Application No. 61/439,085 filed on Feb. 3, 2011 and is herein incorporated by reference in its entirety.

TECHNICAL FIELD

Embodiments generally relate to a system and method for allocating power to a plurality of displays on a single AC circuit while controlling the power consumption of the displays.

BACKGROUND OF THE ART

Electronic displays are now being installed throughout public sites for a number of different reasons (advertising, information, entertainment, menu boards, ticket counters, etc.). Of course, while installing electronic displays at public sites there must be adequate power present to drive the electronic displays. In some applications, multiple displays may be installed at a single location and it may not be feasible or desirable to establish individual circuits for each electronic display. Thus, it is now desirable for multiple electronic displays to share a single AC circuit.

However, when displays are used at public sites, especially outdoor environments or other situations where the ambient light levels are high, the light which is emitted from the display must compete with the amount of ambient light in the present environment. Thus, the displays may be required to produce a large amount of light in order to provide adequate picture quality for the environment. When multiple displays are installed on a single AC circuit, the ability for each display to produce large amounts of light (and draw large amounts of current) is limited by the maximum current level of the AC circuit. In many applications, the AC circuits being used for the displays are in areas where the AC circuit's maximum current may be on the order of 20 Amps.

It is typically undesirable to allow the installed displays to exceed the maximum current allowed by the AC circuit as this can typically lead to tripped breakers or blown fuses which can be time consuming and costly to reset or replace. Therefore, it is desirable to have multiple displays share a single AC circuit without exceeding the maximum current level allowed by the circuit. In other applications it may be desirable to limit the amount of current drawn by the displays for energy conservation reasons, rather than the limits placed on the circuit itself. Therefore, it is also desirable to group several displays together on a single circuit while limiting their power consumption in an effort to conserve energy.

SUMMARY OF THE EXEMPLARY EMBODIMENTS

Exemplary embodiments include a system and method for dynamically sharing a single AC circuit for a plurality of electronic displays while limiting the power consumption (current draw) of the displays. An exemplary system measures the amount of ambient light contacting each of the display surfaces and allocates power accordingly. As the sun moves across the sky, the solar loading on the various displays may change, allowing the exemplary embodiments to transfer power to the display which requires a higher brightness level. Further, the displays can maintain optimum performance without exceeding the maximum current level for the circuit.

The foregoing and other features and advantages of the present invention will be apparent from the following more detailed description of the particular embodiments, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

FIG. **1** is a schematic of the basic components for controlling the brightness of several displays in response to ambient light measurements and total current draw.

FIG. **2** is a flow chart showing one embodiment of the logic for controlling the brightness of several displays in response to ambient light measurements and total current draw.

FIG. **3** is a flow chart showing another embodiment of the logic for controlling the brightness of several displays in response to ambient light measurements and total current draw where optional limit tests are used.

FIG. **4** is an illustration of one exemplary application for the various embodiments of the system and method described herein.

DETAILED DESCRIPTION

The invention is described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

It will be understood that, although the terms first, second, third, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Embodiments of the invention are described herein with reference to schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of the invention.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

FIG. **1** is a schematic of the basic components for controlling the brightness of several displays in response to ambient light measurements and total current draw. The incoming power from the AC circuit is preferably measured using a current sensor **10**, where this measurement (IL) is sent to a power load sharing controller **50**. The incoming power is preferably distributed to each display on the circuit; here display **20**, display **25**, and display n (representing any number of additional displays that may be connected to the AC circuit). Each display preferably has similar components, so the components for each display will now be described with respect to display **20**. Preferably, display **20** is equipped with a brightness controller **21** which controls the brightness level for display **20**. Also preferably, display **20** is also equipped with an ambient light sensor **22** which is placed to measure the amount of ambient light that is contacting the display **20**, preferably the amount of ambient light that is contacting the image-producing face of the display **20**. Once the ambient light level has been measured, the resulting data (S**1**) is transmitted to the power load sharing controller **50** for analysis. As shown in the figure, the power load sharing controller **50** is preferably in electrical communication with the current sensor **10**, ambient light sensor **22**, and the brightness controller **21**.

The power load sharing controller **50** may be any commercially available software driver/processor, control system, or microcontroller. The power load sharing controller **50** may analyze the incoming data from the current sensor **10** and ambient light sensors to produce a brightness setting (B_n) for each display, and sends B_n to the brightness controller **21**. In an exemplary embodiment, the brightness controller **21** may be a circuit card assembly with an onboard microcontroller running embedded software. In a further embodiment, the brightness controller could be a pulse-width modulator (PWM), analog voltage, or a value sent to a backlight or display brightness control chip. In general, the brightness controller **21** accepts B_n for the display and then drives the display to accommodate the brightness setting B_n.

FIG. **2** is a flow chart showing one embodiment of the logic for controlling the brightness of several displays in response to ambient light measurements and total current draw. In general terms, an exemplary system asks each display how bright they would like to be, depending on the measurements coming from the ambient light sensors. The system would then determine the amount of current being used by the displays at the present time, and decide whether the displays may be driven at their desired brightness without exceeding the maximum current allowed by the circuit. If yes, each display is given the amount of power necessary to achieve their desired brightness. If no, the amount of power sent to the displays is reduced such that the maximum allowable current is utilized without overloading the circuit. Any embodiment which achieves these general guidelines would fall within the scope of the invention.

Specifically referring to the embodiment shown in FIG. **2**, the various terms are used to represent the following:

Im—total measured line current running to all displays.

Ic—maximum allowed current from the electrical circuit.

Ia—maximum allowed current. May be set for each application, but should preferably be less than Ic.

t—tolerance of Ia. This tolerance is optional, and may be set at any value for the particular system. The selection of t may depend upon the refresh rate of the system, speed of the processor/sensors, as well as other operational parameters.

Sn—Ambient Light Sensor value from each display.

F{Sn}—display-specific function that converts Sn to desired brightness. This may be a linear function, non-linear function, or a basic lookup table.

Dn—desired brightness setting for each display. Dn=F{Sn}.

k—common derating value applied to each display's desired brightness value. This value can vary anywhere between a selected min/max and the precise amount to increase/decrease k may be the result of a linear function, non-linear function, constant increment, or a basic lookup table. Here, for explanatory purposes, the values can vary anywhere between 0 and 1, and are incrementally increased/decreased by a pre-selected Δk.

Bn—Brightness setting for each display. Bn=k*Dn.

This embodiment begins by setting k=0 and reading the data from the current sensor (Im) and ambient light sensors (Sn). The desired brightness for each display is preferably calculated as Dn=F{Sn}. At this point, the total current (Im) is compared to the maximum allowable current plus an optional tolerance value (Ia+t). If higher, k is decreased. If lower, no action is taken. The system then preferably compares the total current (Im) to the maximum allowable current minus an optional tolerance value (Ia−t). If less, k is increased. If greater, no action is taken. The brightness setting (Bn) for each display is then calculated and sent to each display as Bn=Dn*k. With these new brightness settings, the system then returns to the beginning of the loop and reads the data from the current sensor (Im) and ambient light sensors (Sn).

Thus, in this embodiment, k is used to control the relative amount of current that is sent to each display. Here, if k=1 each display receives the entire amount of current that is desired by each display. Further, if k=0.5 each display receives roughly half of the amount of current that is desired by the display. In this embodiment, because k begins at 0, at startup each display begins dark and slowly increases in power while ensuring that the total current draw does not exceed the maximum current level for the circuit. The amount that k is increased/decreased each time can be driven by a linear function, non-linear function, constant increment, or basic lookup table.

FIG. **3** is a flow chart showing another embodiment of the logic for controlling the brightness of several displays in response to ambient light measurements and total current draw where optional limit tests are used.

For this embodiment, the various terms are used to represent the following:

IL—total measured line current running to all displays.

IC—maximum allowed current from the electrical circuit.

IA—maximum allowed current. Can be set by the end user. In some embodiments, IA is typically 80%-90% of IC.

t—tolerance of IA.

n—subscript that denotes display number.

Sn—Ambient Light Sensor value from each display.

Gn—display-specific constant that converts Sn to desired brightness.

Dn—desired brightness setting for each display. Here, a linear relationship is used: Dn=Gn*Sn.

LU—Upper allowable limit of desired brightness—may be selected for each display or for all displays.

LL—Lower allowable limit of desired brightness—may be selected for each display or for all displays.

K—common derating value applied to each display's desired brightness value. Range is from 0 to 1. Initialized to 0.

ΔK—increment value for K. May be any value that the user desires, in this embodiment ΔK=0.05.

This embodiment begins by setting K=0 and reading the data from the current sensor (IL) and ambient light sensors (Sn). The desired brightness for each display is preferably calculated as Dn=Gn*Sn. In this embodiment, limit tests are then ran to determine if the desired brightness for each display is within the acceptable range between the lower limit (LL) and upper limit (LU). If the desired brightness for any display is greater than the upper limit (LU), the desired brightness for that display is set to the value of the upper limit (LU). If the desired brightness for any display is less than the lower limit (LL), the desired brightness for that display is set to the value of the lower limit (LL).

At this point, the total current (IL) is compared to the maximum allowable current plus a tolerance value (IA+t). If higher, ΔK is subtracted from K and a limit test is ran to determine if K is now less than zero (if so, K is set to zero). If lower, no action is taken. The system then preferably compares the total current (IL) to the maximum allowable current minus a tolerance value (IA−t). If less, ΔK is added to K and may be ran through a limit check to determine if k has now exceeded the max value (here 1); and if so K is set to the max value (here 1). If greater, no action is taken. The brightness setting (Bn) for each display is then calculated and sent to each display as Bn=Dn*K. With these new brightness settings, the system then returns to the beginning of the loop and reads the data from the current sensor (IL) and ambient light sensors (Sn).

FIG. **4** is an illustration of one exemplary application for the various embodiments of the system and method described herein. In this application, a first display **100** and second display **110** are placed in a back-to-back orientation and share a single AC circuit. Thus, the image-producing surface **101** of the first display **100** faces the opposite direction as the image-producing surface **111** of the second display **110**. In this orientation, as the sun passes from sunrise (A.M.) to sunset (P.M.) the solar loading will transfer from the first display **100** to the second display **110**. Thus, the first display **100** will require most of the power in the A.M. and A.M./Noon position while the second display **110** will require most of the power in the P.M./Noon and P.M. positions. As each display contains an ambient light sensor, the variance in solar loading on each display is detected and the desired brightness of each display is accordingly adjusted. The system and method described above can be used to allow the displays **100** and **110** to transfer power back and forth depending upon the position of the sun (ambient light measurements) while sharing a single AC circuit without exceeding the maximum current limits for the circuit.

It is to be understood that the spirit and scope of the disclosed embodiments are not limited to any particular type of display. Embodiments may be used in conjunction with any type of electronic display, including but not limited to: LCD, plasma, OLED, light emitting polymer (LEP), and organic electro luminescence (OEL). Furthermore, the various embodiments may be used with displays of other types including those not yet discovered. While the embodiments herein may be used in outdoor environments, they are not limited to such applications. Thus, the embodiments herein may be used in indoor environments as well, where multiple displays must share a single AC circuit.

Having shown and described a preferred embodiment of the invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

What is claimed is:

1. A method for allocating power between a first and second display, comprising the steps of:

selecting a maximum allowable total current draw for the first and second display;

measuring the amount of ambient light contacting the first display;

measuring the amount of ambient light contacting the second display;

calculating a desired brightness for the first display;

calculating a desired brightness for the second display;

measuring the amount of total current being drawn by the first and second displays; and

determining if the first and second displays can be driven to their respective desired brightness without exceeding the maximum allowable total current draw and

driving the first and second displays at their desired brightness if yes, and

reducing the respective desired brightnesses and driving the first and second displays at the reduced brightness if no;

wherein the step of reducing the respective desired brightness is performed by applying a common derating value to the first and second display's desired brightness value.

2. The method of claim **1** wherein:

the first and second displays are positioned so that they are not co-planar.

3. The method of claim **1** wherein:

the first and second displays are liquid crystal displays.

4. The method of claim **1** wherein:

the first and second displays are OLED displays.

5. A method for allocating power between a first and second display, comprising the steps of:

(A) selecting a common derating value (k) which varies between k_{min} and k_{max} where k represents the relative amount of current to be sent to each display;

(B) setting k equal to k_{min};

(C) selecting a maximum total current draw (IA) for the two displays;

(D) selecting a tolerance (t) for (IA);

(E) measuring the amount of ambient light contacting the first display;

(F) measuring the amount of ambient light contacting the second display;

(G) calculating a desired brightness (D_1) for the first display based on the measured amount of ambient light;

(H) calculating a desired brightness (D_2) for the second display based on the measured amount of ambient light;

(I) measuring the amount of total current (IL) being drawn by the first and second displays;

(J) increasing k if IL<IA−t;

(K) decreasing k if IL>IA+t;

(L) applying k to D_1 to create brightness setting (B_1);

(M) applying k to D_2 to create brightness setting (B_2);

(N) driving the first display at B_1;

(O) driving the second display at B_2; and

(P) repeating steps (E)-(O).

6. The method of claim **5** further comprising the steps of:

setting $k=k_{min}$ if $k<k_{min}$ and

setting $k=k_{max}$ if $k>k_{max}$.

7. The method of claim **5** further comprising the steps of:

selecting a maximum brightness (LU) for the first and second displays;

selecting a minimum brightness (LL) for the first and second displays;

setting B_1=LU if B_1>LU;

setting B_2=LU if B_2>LU;

setting B_1=LL if B_1<LL; and

setting B_2=LL if B_2<LL.

8. The method of claim **5** wherein:

k_{min} is equal to 0; and

k_{max} is equal to 1.

9. The method of claim **5** wherein:

the step of applying k to D_1 is performed by multiplying k with D_1; and

the step of applying k to D_2 is performed by multiplying k with D_2.

10. The method of claim **5** wherein:

the first and second displays are OLED displays.

11. The method of claim **5** wherein:

the first and second displays are liquid crystal displays.

* * * * *